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EXAMINER

CHANG, VICTOR S

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**BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES**

Application Number: 09/856,468
Filing Date: June 07, 2001
Appellant(s): HIRAI ET AL.

David Nikaido and Robert S. Green
For Appellant

EXAMINER'S ANSWER

This is in response to the appeal brief filed 11/4/2004 appealing from the Office action mailed 8/4/2004; and issues raised by the Board dated 8/31/2005.

Introduction

This Supplemental Examiner's Answer is a response to an issue raised by the Board regarding the computer generated translation of JP 08-174590, which is relied upon in the Examiner's Answer dated 1/12/2005. In particular, in response to the Board's statement "The computer generated translation falls short. A translation that reflects the disclosure of the original Japanese document using proper English is required before we can review the rejection on appeal. The Examiner may also wish to re-evaluate whether the English Translation once obtained, of Masahiro, alone, makes obvious, the claimed subject matter" (Remand, page 2), an English Translation of JP 08-174590 by McElroy Translation Company has been obtained, as attached. Further, the Examiner has re-evaluated and updated the grounds of rejection as follows. It should be noted that English Translation has provided essentially the same basis of reasoning as the computer generated translation.

Grounds of Rejection

- The following ground(s) of rejection are applicable to the appealed claims:

Claims 1, 3-8 and 10-20 are rejected under 35 U.S.C. 103(a) as being unpatentable over JP 08-174590 (English Translation by McElroy Translation Company) in view of Park (US 5475037).

JP '590 relates to a thermoplastic polyester type resin foamed molded body, which is obtained by the fusion (bonding) of thermoplastic polyester type resin preliminarily (pre-expanded) foamed particles. The method steps of making the foamed

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molded body are: (1) a thermoplastic polyester type resin containing a foaming agent is fused with an extruder, released into the atmosphere, (2) the extruded foamed body before the completion of foaming or after the completion of foaming is cut to yield preliminarily foamed (pre-expanded) particles, and then (3) the preliminarily foamed (pre-expanded) particles are charged into a mold, and the preliminarily foamed particles are heated and expanded to form a foamed molded body (paragraph 0005). The density of the foamed molded body obtained in the present invention is 0.02 to 0.7 g/cm³. If it is more than 0.7 g/cm³, the light weight characteristics will be poor. If it is less than 0.02 g/cm³, the extrusion foaming for the manufacture of the preliminarily foamed particles will be difficult (paragraph 0014). JP '590 expressly teaches that the crystallinity of the pre-expanded foamed particles is less than 25%. Desirably, it is preferably less than 20%, even more preferably less than 15%. If the crystallinity of the preliminarily foamed particles is more than 25%, the secondary foaming power is weakened during foaming molding by heating and expanding. Furthermore, since the fusion of the preliminarily foamed particles is poor, it will become a foamed molded body with numerous pores and low in strength (paragraph 0008). Finally, in an Example, JP '590 shows that pre-expanded particles is cut from a foamed polyester sheet which has a density of 0.2 g/cm³, and has a crystallinity of 10%, prior to molding (paragraph 0018).

For claim 1, JP '590 expressly teaches that the pre-expanded particles have a low crystallinity of 25% or less and a density of 0.2 g/cm³, which reads on the instant invention as claimed. It is noted that JP '590 is silent about the exact composition of the polyester resin for forming the pre-expanded particles, and its crystallization peak

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temperature. Nevertheless, JP '590 does teach that suitable polyester resins are obtained by the reaction of a dihydric alcohol in a dicarboxylic acid. As the dicarboxylic acid, terephthalic acid is often used. However, it can be butylene dicarboxylic acid, isophthalic acid, 2, 6 naphthalene dicarboxylic acid, etc. On the other hand, as the dihydric alcohol, ethylene glycol is often used. However, it can be butylenes glycol, cyclohexane dimethanol, etc. (paragraph 0015). Additionally, it is noted that Park's invention is directed to a low density foam of amorphous polyethylene terephthalate copolymer (Abstract). Park teaches that in contrast to typical crystalline polyethylene terephthalate (PET) which has a crystallization half-time is less than 10 second, his invention employs an amorphous PET which either does not crystallize or has a crystallization half-time longer than about one hour (i.e., crystallizes at a slow rate) (column 2, lines 40-54). Park also expressly teaches that generally the amorphous polyester resins may be produced by introducing irregularity in the polymer chains. Such irregularity may be introduced in the molecular chains by utilizing and effecting polymerization in the presence of a plurality of diacids, diols, or both, such as isophthalic acid, cyclohexanedimethanol, or mixtures of both. Generally, amorphous polyesters are produced by the incorporation of relatively large amounts (about 15% to about 50%) of isophthalic acid or cyclohexanedimethanol or both in the polymeric structure (column 2, line 59 to column 3, line 16). The Examiner notes that Park's teaching clearly shows that irregularity in the polymer chain disrupts structural regularity required for crystallinity, and since Park expressly teaches that greater than 15% co-monomers is required to impart amorphous property, Park implicitly teaches that when

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the amount of co-monomers (e.g., isophthalic acid or cyclohexanedimethanol for introducing structural irregularity to slow down crystallization) is less than 15%, the crystallinity of PET is reduced, but is not to the degree of being considered as amorphous. As such, in the absence of unexpected results, it would have been obvious to one skilled in the art of molding pre-expanded polyester particles to select a polyester resin having a reduced crystallization rate, formed by incorporating a suitable small amount (less than 15%) of isophthalic acid and/or cyclohexanedimethanol co-monomers, as implicitly taught by Park, motivated by the desire to obtain a pre-expanded foam particle with a reduced crystallinity of less than 25%, as taught by JP '590, motivated by the desire to obtain improved fusion between particles for a stronger foamed molded body. Regarding the crystallization peak temperature, it is the Examiner's position that, in the absence of evidence to the contrary, since the combined teachings of JP '590 and Park read on the composition of the aromatic polyester resin as claimed, a suitable crystallization peak temperature is either anticipated or obviously provided by once a suitable copolyester composition with reduced crystallinity is selected. It should be noted that where the claimed and prior art products are shown to be identical or substantially identical in structure or composition, or are produced by identical or substantially identical processes, a *prima facie* case of either anticipation or obviousness has been established. See MPEP § 2112.01. Additionally, it is noted Applicants have admitted that "The crystallization peak temperature is a function of the materials" (Appeal Brief, page 11, top paragraph).

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For claim 3, the Examiner notes that the common knowledge or well-known in the art statement (incorporating small amount of polytetrafluoroethylene particulates as a foam nucleating agent is old and well known, as evidenced by the state of the art Allen et al. (US 4683247) which teaches the use of polytetrafluoroethylene particulates as a foam nucleating agent (column 1, lines 51-55) is taken to be admitted prior art because Applicants failed to traverse the Examiner's assertion of official notice.

For claims 4 and 5, JP '590 teaches that the foamed extrudate was cut into pre-expanded foam particles as set forth above. Further, JP '590 teaches that the various foam shapes, such as a rod-like, tabular, sheet-like, etc., can be made (paragraphs 0006 and 0007).

For claim 6, JP '590 is silent about the melt tension of the crystalline aromatic polyester resin. However, since the combined teachings of JP '590 and Park read on the composition of the aromatic polyester resin as claimed, it is the Examiner's position that, in the absence of evidence to the contrary, a suitable melt tension is also either anticipated or obviously provided by once a suitable copolyester composition with reduced crystallinity is selected.

Similarly, for claim 7, JP '590 is silent about the open cell ratio. However, since the combined teachings of JP '590 and Park read on the composition of the aromatic polyester resin as claimed, and the same process (melt extrusion and cutting) are used to form the pre-expanded foam particles, it is the examiner's position that, in the absence of evidence to the contrary, an open cell ratio in the range of from 5 to 35% is

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either anticipated or obviously provided, once the product a suitable copolyester is selected.

For claim 8, JP '590 teaches that it is a common practice to carry out a post expansion of the pre-expanded particles by pressure treatment (paragraph 0013).

For claim 10, JP '590 teaches that a polyester foam molding is obtained by first filling up a metal mold with pre-expanded foam particles, then carry out further heat expansion, as set forth above.

For claim 11, JP '590 teaches that the density of a molded foam is 0.02-0.7 g/cm³. As to the fusion ratio, the Examiner repeats that, in the absence of evidence to the contrary, since the combined teachings of JP '590 and Park read on the composition of instant invention as claimed, and also forming the foamed molded body by the same as the instant claimed invention, it is the Examiner's position that a suitable fusion ratio is either anticipated or obviously provided by practicing the teachings of prior art.

For claims 12 and 13, the Examiner notes that the common knowledge or well-known in the art statement (it is believed that molding a foamed article with a layer of film or sheet as a skin layer is old and well known. Further, in the absence of unexpected results, it would have been obvious to one of ordinary skill in the art to mold the article with a suitable amount peel strength between the foam core and the skin layer, motivated by the desire to obtain a durable molded composite foam article) in the prior Office action (see Office action dated 4/2/2003, page 6) is taken to be admitted prior art because Applicants failed to traverse the Examiner's assertion of official notice.

For the product-by-process claims 14, 18 and 20, the Examiner notes that Applicant must show that the resultant article is patentably distinct from those taught by the reference. Therefore, these limitations at the present time have not been given patentable weight.

For claims 15, 16, 17 and 19, they repeat the same subject matter of claims 3 and 5; claims 15 and 6; claims 16 and 8; and claims 18 and 11, respectively, and as such they are also rejected, as set forth above.

Issues Raised by the Board

The Examiner repeats that in response to the issues raised by the Board, an English Translation of JP 08-174590 by McElroy Translation Company has been obtained, as attached. Further, the Examiner has re-evaluated the grounds of rejection, and updated the Office action by referring to the basis of reasoning in the English Translation. It should be noted that since English Translation has provided essentially the same basis of reasoning as the computer generated translation, the original grounds

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of rejection has been maintained. In particular, since JP '590 lacks a teaching regarding how the crystallization rate is affected by the co-monomers, a secondary reference by Park is necessary, as set forth above.

For the above reasons, it is believed that the rejections should be sustained.


Respectfully submitted,



Victor S Chang
Examiner
Art Unit 1771

September 26, 2005

Conferees
Terrel Morris 
Harold Pyon



TERREL MORRIS
SUPERVISORY PATENT EXAMINER
TECHNOLOGY CENTER 1700

PTO 05-6056

Japanese Kokai Patent Application No.
Hei 8 [1996]-174590

**THERMOPLASTIC POLYESTER TYPE RESIN FOAMED MOLDED BODY, AND
METHODS FOR THE MANUFACTURE OF THERMOPLASTIC POLYESTER TYPE RESIN
PRELIMINARILY FOAMED PARTICLES AND OF THERMOPLASTIC POLYESTER TYPE
RESIN FOAMED MOLDED BODY FROM SAID PRELIMINARILY FOAMED PARTICLES**

Masahiro Niido, et al.

UNITED STATES PATENT AND TRADEMARK OFFICE
WASHINGTON, D.C. SEPTEMBER 2005
TRANSLATED BY THE MCELROY TRANSLATION COMPANY

JAPANESE PATENT OFFICE (JP)
PATENT JOURNAL (A)
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THERMOPLASTIC POLYESTER TYPE RESIN FOAMED MOLDED BODY, AND
METHODS FOR THE MANUFACTURE OF THERMOPLASTIC POLYESTER TYPE RESIN
PRELIMINARILY FOAMED PARTICLES AND OF THERMOPLASTIC POLYESTER TYPE
RESIN FOAMED MOLDED BODY FROM SAID PRELIMINARILY FOAMED PARTICLES

[Netsu kasosei polyester kei jushi happo seikei tai, netsu kasosei polyester kei jushi yobi happo
ryushi oyobi gai yobi happo ryushi kara netsu kasosei polyester kei jushi happo seikei tai no
seizo hoho]

Applicant:	000006769 Sekisui Synthetic Product Ind. Co., Ltd.
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Inventors:	Masahiro Niido, et al.
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Claims

1. A thermoplastic polyester type resin foamed molded body characterized by the fact that, as the foamed molded body obtained by the fusion of thermoplastic polyester type resin

preliminarily foamed particles, its apparent density is $0.02-0.7 \text{ g/cm}^3$ and the crystallinity of the foamed body is more than 15%.

2. A method for the manufacture of thermoplastic polyester type resin preliminarily foamed particles characterized by the fact that, in the method for the manufacture of preliminarily foamed particles by the fusion of a thermoplastic polyester type resin containing a foaming agent and by extrusion foaming with an extruder and then cutting this extruded foamed body, the crystallinity of the preliminarily foamed particles is less than 25%.

3. The method for the manufacture of preliminarily foamed particles described in Claim 2 characterized by the fact that the fusion crystallization temperature of the thermoplastic polyester type resin composition is lower by more than 40°C than the crystal melting point.

4. A method for the manufacture of a thermoplastic polyester type resin foamed molded body characterized by the fact that a thermoplastic polyester type resin containing a foaming agent is fused, subjected to extrusion foaming with an extruder, this extruded foamed body is cut to yield preliminarily foamed particles, and then the preliminarily foamed particles are charged into an enclosed or unenclosed mold, and the preliminarily foamed particles are heated and expanded to cause the fusion of the preliminarily foamed particles to form a foamed molded body.

Detailed explanation of the invention

[0001]

Industrial application field

The present invention relates to a foamed molded body of a thermoplastic polyester type resin (this will be called PAT resin hereafter) and its manufacturing method. Furthermore, it relates to preliminarily foamed particles for the manufacture of said foamed molded body and their manufacturing method.

[0002]

Prior art

The PAT resin has excellent properties that are not found in polystyrene or polyethylene. Its rigidity is high and its shape stability is good. Its chemical resistance and so on are excellent. It has been used in a variety of fields. Therefore, in the same manner as for polystyrene or polyethylene, attempts have been made to foam the PAT to prepare PAT foamed molded bodies that are light weight and excellent in heat resistance, heat insulation characteristics, buffer characteristics, etc. As a method for the preparation of these foamed molded bodies, a method is available for passing through a process for the impregnation of a foaming agent into the resin (impregnation), a process for heating the resin impregnated with the foaming agent to yield the

preliminarily foamed particles (primary foaming), and a process for charging the preliminarily foamed particles into a mold, followed by heating and expanding to yield a foamed molded body (secondary foaming).

[0003]

However, since the PAT resin has good gas barrier characteristics, it takes a long time to impregnate the foaming agent. Therefore, with this method, there have been problems in terms of time, cost, and labor. For example, it is described in Japanese Kokai Patent Application No. Sho 51 [1976]-50365 in regard to a polyester type latent foaming molded material obtained by the impregnation of a low boiling point liquid as a nonsolvent or a difficult solvent of the polyester into the un-stretched molded material prepared by wet process molding or dry process molding of a high melting point polyester (the PAT resin). It is described that, by heating this latent foaming molded material to a temperature above the plasticizing temperature, an extremely bulky foamed body is obtained. However, it is described that a long [time] is preferred to impregnate a low boiling point liquid into this polyester and impregnation is carried out for more than 4-5 h. Thus, enormous time is required for the impregnation of a solvent in the polyester, and the crystallinity of the PAT resin is increased by heating during impregnation and during the preparation of the preliminarily foamed particles. Even if the preliminarily foamed particles of this PAT resin are subjected to secondary foaming molding inside the mold frame, the preliminarily foamed particles do not fuse with each other and thus a molded body in the mold shape cannot be obtained. Therefore, in this patent application, there is no description in regard to the secondary foaming molding of the preliminarily foamed particles inside the mold. On the other hand, as heat-resistant foamed molded bodies, polypropylene type materials as described in Japanese Kokoku Patent No. Sho 59 [1984]-43492 and polystyrene-polyphenylene ether type materials as described in Japanese Kokai Patent Application No. Hei 4 [1992]-345635 are well-known. However, they have problems in chemical resistance (oil resistance) and in usage the high-temperature areas.

[0004]

Problems to be solved by the invention

As a result of a variety of investigations in order to solve the problems described previously, the present inventors have discovered that, if a foaming agent is mixed in the PAT resin by using an extruder, the PAT resin containing the foaming agent is released from the extruder into the atmosphere, and the foamed particles obtained by cutting of the extruded foamed body before the completion of foaming or after the completion of foaming are charged into the mold to cause the secondary foaming and molding, and the particles are mutually fused

to yield a foamed molded body. The present invention has thus been accomplished. The objective of the present invention is to provide a foamed molded body that is light weight and having a heat resistance obtained by charging the preliminarily foamed particles into the mold to cause the secondary foaming and molding. At the same time, in order to manufacture preliminarily foamed particles to obtain said foamed molded body, it provides a method for the manufacture of the preliminarily foamed particles with excellent productivity by simplifying the process for the impregnation of the foaming agent into the PAT resin and the process for heating and foaming the PAT resin containing the foaming agent to yield the preliminarily foamed particles.

[0005]

Means to solve the problems

The present invention has a gist of a thermoplastic polyester type resin foamed molded body characterized by the fact that, as the foamed molded body obtained by the fusion of thermoplastic polyester type resin preliminarily foamed particles, its apparent density is 0.02-0.7 g/cm³ and the crystallinity of the foamed body is more than 15%. Furthermore, the present invention also includes a method for the manufacture of a thermoplastic polyester type resin foamed molded body like that described previously. Such a method is characterized by the fact that a thermoplastic polyester type resin containing a foaming agent is fused with an extruder, released from the clasps into the atmosphere, the extruded foamed body before the completion of foaming or after the completion of foaming is cut to yield preliminarily foamed particles, and then the preliminarily foamed particles are charged into an enclosed or unenclosed mold, and the preliminarily foamed particles are heated and expanded to form a foamed molded body.

[0006]

There are no special restrictions in regard to the extruders that can be used in the present invention. In general, uniaxial extruders, biaxial extruders and so on can be used in extrusion foaming and molding of this type. Furthermore, a tandem type by linking of these is also acceptable. As the clasps that can be used in the present invention, a variety of them can be used. For example, an annular clasp, a flat clasp, a nozzle clasp, as well as a multi-nozzle clasp obtained by installing multiple nozzles, and so on can be mentioned. By using these clasps, a sheet-shaped foamed body, a plate-shaped foamed body, a rod-shaped foamed body and so on can be prepared. In particular, in regard to the shape of the foamed body, any shape is acceptable.

[0007]

In the present invention, in order to have the specified shape of the foamed body mentioned previously, a variety of methods can be used. For example, in the case of extrusion from an annular clasp, it may proceed on a mandrel to yield a sheet form. In the case of extrusion from the flat clasp, a sheet form can be obtained with a chill roll [transliterated]. Furthermore, in order to obtain a plate-shaped foamed body having a [specific] thickness, it is allowed to proceed while it is contacted closely with a pair of metal plates to yield the specified form. In the present invention, the foamed body described previously is cut off to yield preliminarily foamed particles. There are no special restrictions in regard to the cutting method or time period. A variety of methods can be used. For example, the foamed body extruded from a nozzle is passed through a water tank before the completion of foaming or after the completion of foaming for cooling, and then cut into the specified shape and size with a pelletizer or the like to yield the preliminarily foamed particles. Furthermore, it can also be extruded from the clasp and cut off immediately before the completion of foaming or after the completion of foaming to yield the preliminarily foamed particles. Moreover, the material extruded in a sheet form, after being stored in a roll form with a rolling machine or the like, can be cut off with a crushing machine or a cutting machine to yield the preliminarily foamed particles. As the preliminarily foamed particles, for example, those with circular columnar, square, chip or a variety of other shapes can be used.

[0008]

In the present invention, as a method for cooling the foamed body, air cooling, water cooling, contacting with a cooling apparatus having a temperature adjustment, and a variety of other methods can be used. In the present invention, it is desirable that the cooling of the foamed body is carried out as rapidly as possible so that the crystallinity of the preliminarily foamed particles is less than 25%. Desirably, it is preferably less than 20%, even more preferably less than 15%. If the crystallinity of the preliminarily foamed particles is more than 25%, the secondary foaming power is weakened during foaming molding by heating and expanding. Furthermore, since the fusion of the preliminarily foamed particles is poor, it will become a foamed molded body with numerous pores and low in strength. It has been believed that these can be improved by increasing the heating temperature during foaming molding. However, since the crystallization of the preliminarily foamed particles further proceeds by heating at a high temperature, in essence, a high molding temperature to start the melting of the crystals will be required.

[0009]

In the present invention, in the process for the manufacture of preliminarily foamed particles by extrusion foaming, in order to maintain the crystallinity of the preliminarily foamed particles at a low level and in order to improve the fusion of the preliminarily foamed particles during secondary foaming molding, it is desirable to adjust the progress of the crystallization of the preliminarily foamed particles. In the secondary foaming molding, in order to heat and expand the preliminarily foamed particles with steam or the like, crystallization proceeds at the same time as the secondary foaming. If the crystallization proceeds too fast, the secondary foaming power and the fusion of the preliminarily foamed particles will be poor. It will become a foamed molded body with numerous pores and low in strength. The adjustment of the rate of crystallization is to be conducted by the type or the amount of addition of the crystal nucleating agent, the molecular weight of the resin, the modification of the resin, etc. It is desirable that the cold crystallization temperature of the PAT preliminarily foamed particles is higher than the glass transition temperature by more than 40°C. Furthermore, it is desirable that the fusion crystallization temperature of the PAT preliminarily foamed particles is lower than the crystal melting point by more than 40°C, preferably more than 50°C, more preferably more than 55°C.

[0010]

The crystallization temperature, the glass transition temperature, the cold crystallization temperature, the crystal melting point, and the fusion crystallization temperature in the present invention can be measured by using a differential scanning calorimeter (DSC) according to JIS K-7121. For example, if the PAT is the polyethylene terephthalate resin, a measurement sample is charged into the vessel and subjected to heating at a rate of 5°C/min. The cold crystallization heat and the fusion heat as well as the peak temperatures at that time, that is, the cold crystallization temperature and the crystal melting point, are measured. The cold crystallization temperature is the peak temperature at which crystallization occurs during heating. If this temperature is low, it means that the progress of crystallization is fast. In the present invention, it is desirable to adjust the cold crystallization temperature of the PAT preliminarily foamed particles to a value higher than the glass transition temperature by more than 40°C. Furthermore, the crystallinity is calculated according to the following equation.

[0011]

[Mathematical formula 1]

Crystallinity = [Molar fusion heat – Molar cold crystallization heat] x 100/[Molar fusion heat of the perfect crystal PAT resin]

[0012]

Here, the molar fusion heat of the perfect crystal polyethylene terephthalate is 26.9 KJ according to the Polymer Data Handbook (published by Baifukan) and this is used. Furthermore, in the measurement of the fusion crystallization temperature, cooling from the fusion state is carried out at a rate of 5°C/min. The peak temperature of crystallization is measured, and this is the fusion crystallization temperature. If this fusion crystallization temperature is high, it means that the progress of crystallization is fast. In the present invention, it is desirable that the fusion crystallization temperature of the PAT preliminarily foamed particles is adjusted to a value lower than the crystal melting point by more than 40°C, preferably more than 50°C, more preferably more than 55°C. As a method for the formation of the preliminarily foamed particles obtained in the present invention, it is common to use a method in which preliminarily foamed particles are charged into an enclosed or un-enclosed mold and steam is introduced as a heating medium to cause molding.

[0013]

As the heating medium at this time, in addition to steam, it is also possible to use hot wind, oil or the like. However, in order to carry out molding in an efficient manner, steam is effective. After molding, it is cooled and taken out from the mold to yield the molded product. In the case of molding with steam, after the preliminarily foamed particles have been charged into the mold, first of all, steam is blown into the mold at a low pressure (for example, 0.5 kg/cm²: as the gage pressure, the same hereafter) in order to purge the air between particles to the outside. Afterwards, the common method is that the pressure is increased to further cause the secondary foaming of the preliminarily foamed particles for fusion to yield a molded product. The crystallinity of the foamed molded body obtained in the present invention is preferably more than 15%, more preferably more than 20%. If the crystallinity is less than 15%, the heat resistance of the foamed molded product will decrease markedly.

[0014]

Furthermore, the density of the foamed molded body obtained in the present invention is 0.02 to 0.7 g/cm³. If it is more than 0.7 g/cm³, the light weight characteristics will be poor. If it is less than 0.02 g/cm³, the extrusion foaming for the manufacture of the preliminarily foamed particles will be difficult. It is preferably 0.04 to 0.06 [sic] g/cm³, more preferably 0.05 to 0.5 g/cm³. In the present invention, the measurement of the heating dimensional change ratio is carried out in the following manner. The foamed molded body obtained is cut into a size of about 10 cm [length] x 10 [width] cm x 2 cm thickness. The change ratios of various dimensions (length, width and thickness) after the heating treatment and before heating are measured,

respectively. The average of the change in the ratios in the three directions is used as the heating dimensional change ratio. In regard to the heating conditions, the measurement was carried out twice at 140°C for 24 h and at 180°C for 1 h. In the present invention, it is preferable that the dimensional change ratio by heating of the resulting foamed molded body at 140°C for 24 h is less than 5%. Furthermore, it is preferable that the dimensional change ratio by heating at 180°C for 1 h is less than 5%.

[0015]

The PAT resin that can be used in the present invention is a high molecular weight chain-shaped polyester obtained by the reaction of a dihydric alcohol in a dicarboxylic acid. As the dicarboxylic acid, terephthalic acid is often used. However, it can be butylene dicarboxylic acid, isophthalic acid, 2, 6-naphthalene dicarboxylic acid, etc. On the other hand, as the dihydric alcohol, ethylene glycol is often used. However, it can be butylenes glycol, cyclohexane dimethanol, etc. Among the PAT resins mentioned previously, those appropriate for use in the present invention are polyethylene terephthalate, polybutylene terephthalate, polyethylene naphthalate, polycyclohexane terephthalate, and so on. Preferably, it is polyethylene terephthalate or polybutylene terephthalate. More preferably, it is polyethylene terephthalate. Furthermore, the PAT resins mentioned previously can be used alone or after mixing. It is also possible that the PAT resins mentioned previously are used after mixing with other resins. In the case of using other resins, it is necessary that the other resins have a lower molecular weight than the PAT resin.

[0016]

In the present invention, a variety of additives can also be included. For example, a crystal nucleating agent, a foam adjusting agent, a flame retardant, an electrostatic inhibitor, a coloring agent and so on are available. Furthermore, in order to improve the fusion characteristics of the PAT resin, pyromellitic anhydride or other acid dianhydrides, sodium carbonate or other Periodic Table Group Ia or IIa group metal compounds and so on can be added alone or after mixing. As the foaming agents that can be used in the present invention, a variety of substances can be employed. They can be broadly classified into solid compounds that generate gases by decomposition at a temperature above the softening point of the PAT resin, liquids that gasify inside the PAT resin by heating, inert gases that are capable of being dissolved in the PAT resin under pressure, etc. Any of these can be used in the present invention. As the solid compounds, for example, azo dicarbonamide [transliteration], dinitroso pentamethylene tetramine, hydrazol carbonamide [transliteration], sodium bicarbonate and so on are available. The liquids that gasify are, for example, propane, butane, pentane, hexane or other saturated

aliphatic hydrocarbons, benzene, xylene, toluene or other aromatic hydrocarbons, methyl chloride, Freon (a registered trademark) or other halogenated hydrocarbons. As the inert gases, for example, carbon dioxide, nitrogen and so on are available.

[0017]

Application examples

By giving application examples and comparative examples in the following, the excellent points of the present invention will be specifically explained. In the following, "parts" means parts by weight.

Application Example 1

As the PAT resin, PET (TR8580, manufactured by Teijin Co.) was used. First of all, the PET was placed in a dehumidifying-drying machine. The PET was dried at 160°C for 4 h while air with a dew point of -30°C was being circulated. By using the PET described previously, the following mixture was prepared.

PET/100 parts

Pyromellitic anhydride/0.33 part

Sodium carbonate/0.05 part

This mixture was placed in an extruder with a diameter of 65 mm and an L/D ratio of 35, and mixed well at a screw rotational speed of 25 rpm and a barrel temperature of 270-290°C. Butane was pressed in as a foaming agent from the middle of the barrel. The butane was at a ratio of 1 wt% with respect to the mixture. The clasp had an extruding hole of an annular shape. The extruding hole had a slit width of 0.4 mm and an inside diameter of 60 mm. The PET extruded from the extruding hole foamed and proceeded on the cooling mandrel. The inside was contacted with the mandrel for quenching and the outside was blown with air from the air ring for cooling. The mandrel was maintained at 20°C by the circulation of cooling water inside.

[0018]

After passing through the mandrel, the foamed PET sheet in a circular cylindrical shape was cut open to yield a flat sheet and is rolled. The foamed sheet obtained had a density of 0.20 g/cm³, a thickness of 2.0 mm and a width of 645 mm. Furthermore, crystallinities of the surface skin portion and the central portion of the foamed body were 10% and 10.5%, respectively. Furthermore, the crystal melting point of the foamed sheet obtained was 251.5°C, and the fusion crystallization temperature was 195.0°C. The foamed sheet obtained was cut into a chip shape of about 5 mm x 5 mm x 2 mm with a cutting machine. It was then charged into a

mold of 300 mm x 400 mm x 20 mm. After being enclosed, it was heated and expanded under a steam pressure of 0.3 kg/cm² for 30 sec and 1.0 kg/cm² for 120 sec. In doing so, a PET foamed molded body without pores observed between particles of the size of 300 mm x 400 mm x 20 mm was obtained. The crystallinity of the foamed molded body obtained was 23%. The foamed molded body obtained was placed in a constant-temperature bed at 140°C. The dimensional change ratio after heating for 24 h was measured to be 2.8%. Furthermore, the heating dimensional change ratio after being placed in a constant-temperature bed at 180°C for 1 h was 3.3%. The foamed molded body thus obtained was found to be a material excellent in heat resistance.

[0019]

Application Example 2

The experiment was carried out in the same manner as in Application Example 1 except that PET (TR8510, manufactured by Teijin Co.) was used as the PAT resin and the amount of addition of the pyromellitic anhydride was 0.2 parts by weight in Application Example 1. The foamed sheet obtained had a density of 0.20 g/cm³, a thickness of 2.0 mm and a width of 645 mm. Furthermore, crystallinities of the surface skin portion and the central portion of the foamed body were 8.6% and 9.0%, respectively. The crystal melting point was 247.6°C, and the fusion crystallization temperature was 182.1°C. The foamed sheet obtained was cut into a chip shape of about 5 mm x 5 mm x 2 mm with a cutting machine. It was then charged into a mold of 300 mm x 400 mm x 20 mm. After being enclosed, it was heated and expanded under a steam pressure of 0.3 kg/cm² for 30 sec and 1.0 kg/cm² for 120 sec. In doing so, a PET foamed molded body without pores observed between particles of the size of 300 mm x 400 mm x 20 mm was obtained. The crystallinity of the foamed molded body obtained was 21%. The foamed molded body obtained was placed in a constant-temperature bed at 140°C. The dimensional change ratio after heating for 24 h was measured to be 2.5%. Furthermore, the heating dimensional change ratio after being placed in a constant-temperature bed at 180°C for 1 h was 3.2%. The foamed molded body thus obtained was found to be a material excellent in heat resistance.

[0020]

Application Example 3

The experiment was carried out in the same manner as in Application Example 1 except that the clasp had a slit width of 0.3 mm and an inside diameter of 60 mm and trichloromonofluoromethane was used as a foaming agent at 13 parts by weight. The foamed sheet obtained had a density of 0.06 g/cm³, a thickness of 2.0 mm and a width of 645 mm. Furthermore, crystallinities of the surface skin portion and the central portion of the foamed body

were 10.3% and 10.5%, respectively. The crystal melting point was 251.6°C, and the fusion crystallization temperature was 195.5°C. The foamed sheet obtained was cut into a chip shape of about 5 mm x 5 mm x 2 mm with a cutting machine. It was then charged into a mold of 300 mm x 400 mm x 20 mm. After being enclosed, it was heated and expanded under a steam pressure of 0.3 kg/cm² for 30 sec and 1.0 kg/cm² for 120 sec. In doing so, a PET foamed molded body without pores observed between particles of the size of 300 mm x 400 mm x 20 mm was obtained. The crystallinity of the foamed molded body obtained was 25%. The foamed molded body obtained was placed in a constant-temperature bed at 140°C. The dimensional change ratio after heating for 24 h was measured to be 4.5%. Furthermore, the heating dimensional change ratio after being placed in a constant-temperature bed at 180°C for 1 h was 4.8%. The foamed molded body thus obtained was found to be a material excellent in heat resistance.

[0021]

Effect of the invention

As described previously, in the present invention, a thermoplastic polyester type resin impregnated with a foaming agent can be easily obtained because an extruding machine is used in the impregnation of the foaming agent. Since a preliminarily foamed body is manufactured by the fusion of this followed by extrusion foaming, the crystallinity of the preliminarily foamed body can be maintained at less than 25%. As a result, by charging this preliminarily foamed body into the mold followed by secondary foaming molding, a light weight foamed molded body having a heat resistance can be manufactured. Furthermore, even in the method for the manufacture of preliminarily foamed particles, the process for the impregnation of a foaming agent into the PAT resin and the process for the heating foaming of the foaming agent impregnated PAT to yield the preliminarily foamed particles can be simplified to a large extent, and an excellent effect on productivity can be achieved.